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ORIGINAL CLINICAL ARTICLE

Exploring pelvic floor muscle activity in men with lower urinary tract symptoms

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Abstract

Aim: We aimed to explore the utility of the Multiple Array Probe Leiden (MAPLe) device to assess pelvic floor muscle activity in men with lower urinary tract symptoms (LUTS).

Methods: This was an observational cohort study performed at the urology outpatient department of a large teaching hospital in the Netherlands between April and October 2018. We recruited male patients referred for the assessment of LUTS, without a history of prostate surgery, if they had an International Prostate Symptom Score greater than or equal to 8. The MAPLe device was then used to assess the puborectalis, pubococcygeus, iliococcygeus, urogenital diaphragm, and the internal and external anal sphincters during three tasks: a rest period (1 minute), five maximum voluntary contractions (held for 3 seconds each), and three maximal endurance contractions (held for 15 seconds each).

Results: In total, 57 patients were included, 5 of which had diabetes mellitus. Muscle activity at rest was significantly lower than during either contraction task and did not differ between the muscle groups. By contrast, the external anal sphincter had significantly less activity than any other muscle group during the endurance task, and the internal anal sphincter and puborectalis had significantly less activity during the maximum voluntary contraction task. No association was found between pelvic floor muscle activity and LUTS severity during any task.

Conclusion: Pelvic floor muscle activity and LUTS severity appear to be unrelated, but this does not completely exclude the possibility of muscle involvement in the development or experience of symptoms. Further research is needed.

KEYWORDS
electromyography, IPSS, MAPLe, OABSS, observational study, symptom severity

1 | INTRODUCTION

The potential role of pelvic floor muscle function in lower urinary tract symptoms (LUTS) has not been studied thoroughly among men, contrasting starkly with the situation in women.[1,2] This can, at least in part, be explained by difficulties when assessing the male pelvic floor.[3] In a small study using real-time magnetic resonance imaging in healthy male volunteers,[4] functional changes were shown in the pelvic floor before and during micturition. Before voiding, it was noted that there was relaxation of the pelvic floor and widening of the angle between the pubic bone and the ventral prostate. One participant who was unable to void did not have these features.[4] Practical difficulties in the assessment of pelvic floor muscle activity may be overcome using the Multiple Array Probe Leiden (MAPLe) device, an anal probe with a matrix of 24 electrodes capable of registering electromyography (EMG) signals.[5] When placed correctly, the electrodes match to individual pelvic floor muscles. To date, however, validation studies of the MAPLe device have only included healthy subjects, and we are aware of no studies in males with LUTS.

We aimed to explore pelvic floor muscle activity with the MAPLe device in men with LUTS of varying severities.

2 | MATERIALS AND METHODS

2.1 | Study design, setting, and participants

This observational cohort study was conducted at the urology outpatient department of a large teaching hospital in the Netherlands between April and October 2018. We included adult male patients (age ≥ 18 years) referred for the assessment of moderate to severe LUTS with no complications, such as recurrent urinary tract infections or previous prostate surgery for benign or malignant conditions. We excluded patients with poor command of the Dutch language or a history of cancer and/or surgery of the prostate or bladder. The relevant medical ethics committee approved this study (number 171205).

2.2 | Data collection

All men provided written informed consent. LUTS severity was assessed by the International Prostate Symptom Score (IPSS),[6] and the Overactive Bladder Symptom Score (OABSS).[7] Uroflowmetry was performed using an MMS FlowMaster, and was considered representative if the voided volume was greater than or equal to 125 mL.[8] The post-void residual was measured by abdominal ultrasound of the urinary bladder. Transrectal ultrasound was not routinely used.

Directly following the urologist's appointment, researchers performed a final eligibility check to assess symptom severity, excluding those with an IPSS smaller than or equal to 7, and performed an additional assessment of the pelvic floor muscles using the MAPLe device. At this stage, participants were asked to view an instructional video about correct probe placement. The probe was inserted by patients under the supervision of a researcher, who then checked whether the final placement was satisfactory. This was defined as a correct orientation of the probe, to ensure that the sides of the probe equalled the front, back, left, and right. For this, the direction of the attached cables is important. The shape of the MAPLe device, with a notch at the base of the probe, around which the anal sphincter closes, further supports adequate placement.

The MAPLe device is a probe with a matrix of 24 electrodes (six levels, 10 mm apart, on the four different sides of the probe), with which EMG signals can be measured from the different layers and sides of the pelvic floor muscles. In a validation study, Voorham-van der Zalm et al demonstrated with static and dynamic magnetic resonance imaging that placement of the electrodes with respect to the different pelvic floor muscles was accurate.[5]

Performance on three tasks was assessed using the MAPLe device in the supine position: (a) rest (one period for 1 minute); (b) maximum voluntary contractions (five held for 3 seconds each); and (c) maximal endurance contractions (three held for 15 seconds each). The instruction given on how to activate the pelvic floor muscles was "try to hold back bowel movements, passing flatus or gas." Subjects were allowed short rest periods of 5 seconds between each maximum voluntary contraction and 10 seconds between each maximal endurance contraction. Measurements were repeated if the researcher observed co-contraction of the muscles of the abdominal wall or upper legs and/or the absence of an inward movement of the perineum. If the probe was expelled, the researcher manually supported it while the participant repeated the task.

2.3 | Data handling

A visual representation of pelvic floor muscle activity is presented in a tablet application developed for the

MAPLe device. Gray scales (from black to white) represent the microvolt readings for the 24 electrodes, which are graphically presented in a “bull's eye” pattern. After performing the three tasks, a mean microvolt value for each task was calculated by the software and displayed as a summary statistic. For the analyses in this study, however, raw data were needed from each electrode. Novuqare, the developer of the MAPLe device, provided support in retrieving these data. For this, they required us to send an anonymised backup file of the MAPLe application, which was returned as raw data. We could then use those data to calculate the mean microvolt values for all 24 electrodes and all tasks. Subsequently, the readings from electrodes corresponding to specific pelvic floor muscles could be combined based on an established method.[5,9] This resulted in mean microvolt values that represented the m.puborectalis (PR; electrodes 3 and 4 on the left, right, and backside of the probe), m.pubococcygeus and m.iliococcygeus (PIC; electrodes 1 and 2, left, right, and backside), the urogenital diaphragm (UD, electrodes 1 to 5, front side of the probe), the internal anal sphincter (IAS; electrode 5, all side of the probe), and the external anal sphincter (EAS; electrode 6, all side of the probe). Present insights show that the UDF differs from other pelvic floor muscles and consists mainly of membranous and fascial tissues, and should be considered as a functional structure which is crossed by the urethra.

2.4 | Statistical analysis

Patient characteristics are presented as means and standard deviations or as medians and interquartile ranges (IQRs), depending on the data distributions. To explore the differences in pelvic floor muscle activity by muscle group, we presented the outcomes for each muscle per task. Friedman's test was then used to assess the difference in the median microvolt result between each muscle and task, separately. A post hoc Wilcoxon signed-rank test was used to identify differences between pelvic floor muscles or groups. To explore the possible association between symptom severity and pelvic floor muscle activity, we applied Spearman's correlation coefficients for the outcomes of the MAPLe measurement with the OABSS and IPSS. Outcomes were then presented for each of the five muscle groups per task. Finally, we compared the outcomes between men with and without diabetes mellitus, by means of presenting median values and P values for the Spearman correlation coefficient. Because our analyses resulted in multiple comparisons, we applied the Bonferroni adjustment. We considered $P \leq .005$ to be statistically significant in all analyses. IBM SPSS, version 25 (IBM Corp, Armonk, NY) was used for all statistical analyses.

TABLE 1 Patient characteristics (N = 57)

Characteristics	N (%)	Mean ± SD
Age, y		67.1 ± 10.4
BMI, kg/m^2		27.2 ± 3.4
Uroflowmetry (Qmax)		9.4 ± 5.2
Post-void residual		80.6 ± 111.2
Voiding diary, 24 h		
Maximum voided volume, mL		324 ± 149
Frequency, times/24 h		11 ± 4
Nocturia, times/24 h		2 ± 2
IPSS (0-35)		19.2 ± 6.2
Mild (0-7)	0 (0)	
Moderate (8-19)	32 (56)	
Severe (20-35)	25 (44)	
OABSS (0-15)		6.1 ± 3.2
Mild (≤5)	22 (39)	
Moderate (6-11)	33 (58)	
Severe (≥12)	2 (3)	

Abbreviations: BMI, body mass index; IPSS, International Prostate Symptom Score; OABSS, Overactive Bladder Symptom Score.

3 | RESULTS

We included 57 patients in the study, and their characteristics are summarized in Table 1. The participants had a mean age of 67.1 ± 10 years, a mean IPSS of 19.2 ± 6.2, and a mean OABSS of 6.1 ± 3.2. Five men were diagnosed with diabetes mellitus.

During the 1-minute rest task, pelvic floor muscle activity was as follows: 4.4 μV in the PR, 4.4 μV in the PIC, 4.9 μV in the UDF, 5.0 μV in the IAS, and 4.2 μV in the EAS. Differences between these muscle groups were not significant (Figure 1A). Therefore, in the analysis of pelvic floor muscle activity and symptoms, the five muscle groups were combined for the 1-minute rest task. During the maximum voluntary contractions task, the EAS showed significantly lower activity (13.2 μV) than either the IAS (17.3 μV) or the PR (16.8 μV) by the Wilcoxon signed-rank test. EAS activity also did not differ significantly between the UDF and the PIC (Figure 1B). During the endurance task, the EAS (11.9 μV) showed significantly lower activity than the other muscle groups (PR 15.7 μV, IAS 16.0 μV, PIC 16.4 μV, and UD 15.2 μV; Figure 1C).

When comparing the three tasks by muscle group, a clear difference was seen between the rest activity and both the maximum voluntary contraction and endurance tasks. However, the differences between the maximum voluntary contraction tasks and endurance tasks were not significant for any muscle group (Figure 2).

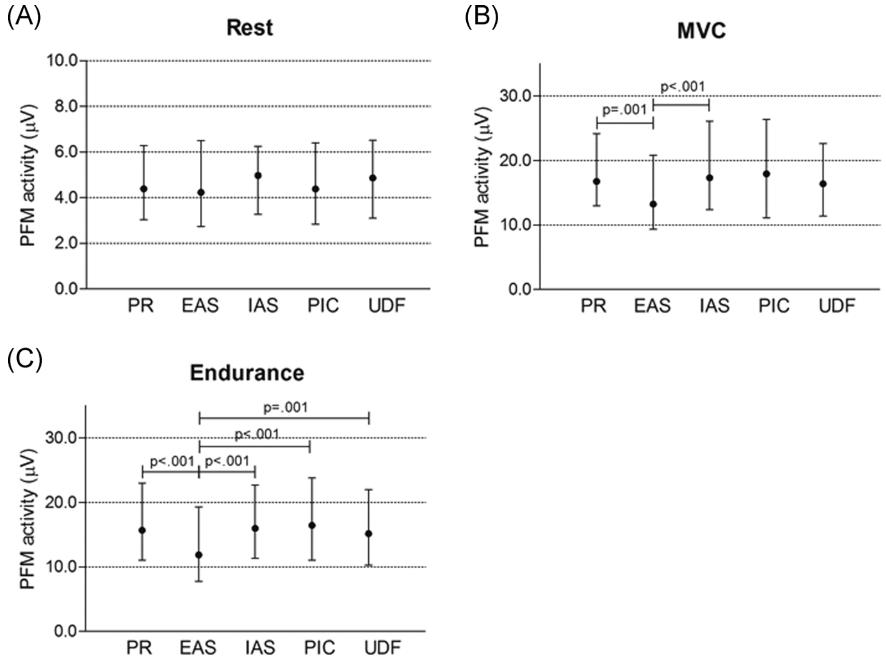

FIGURE 1 A, Median microvolt with interquartile range for each muscle group at rest, (B) MVC, and (C) endurance. *P* values reflect the results from the Wilcoxon signed-ranks test between each muscle group. EAS, external anal sphincter; IAS, internal anal sphincter; MVC, maximum voluntary contraction; PFM, pelvic floor muscle; PIC, pubococcygeus and iliococcygeus; PR, puborectalis; UDF, urogenital diaphragm

No association was found between pelvic floor muscle activity and LUTS severity on any of the three tasks (Table 2). The strongest correlations were found for the IPSS with the IAS (0.19), the PIC (0.18), and the UDF (0.21), but none of these had significant *P* values.

The five men with diabetes were shown to have higher activity of PR, IAS, PIC, and UD in all measurements (Table 3), but differences did not reach the predefined threshold of statistical significance ($P < .005$).

4 | DISCUSSION

We used the MAPLe device to explore the activity of pelvic floor muscles, together with how that activity was associated with symptom severity, in a symptomatic cohort of men, without a history of prostate surgery. Although no association was found despite the large cohort, there remains sufficient reason to consider that our findings do not exclude the possible role of pelvic

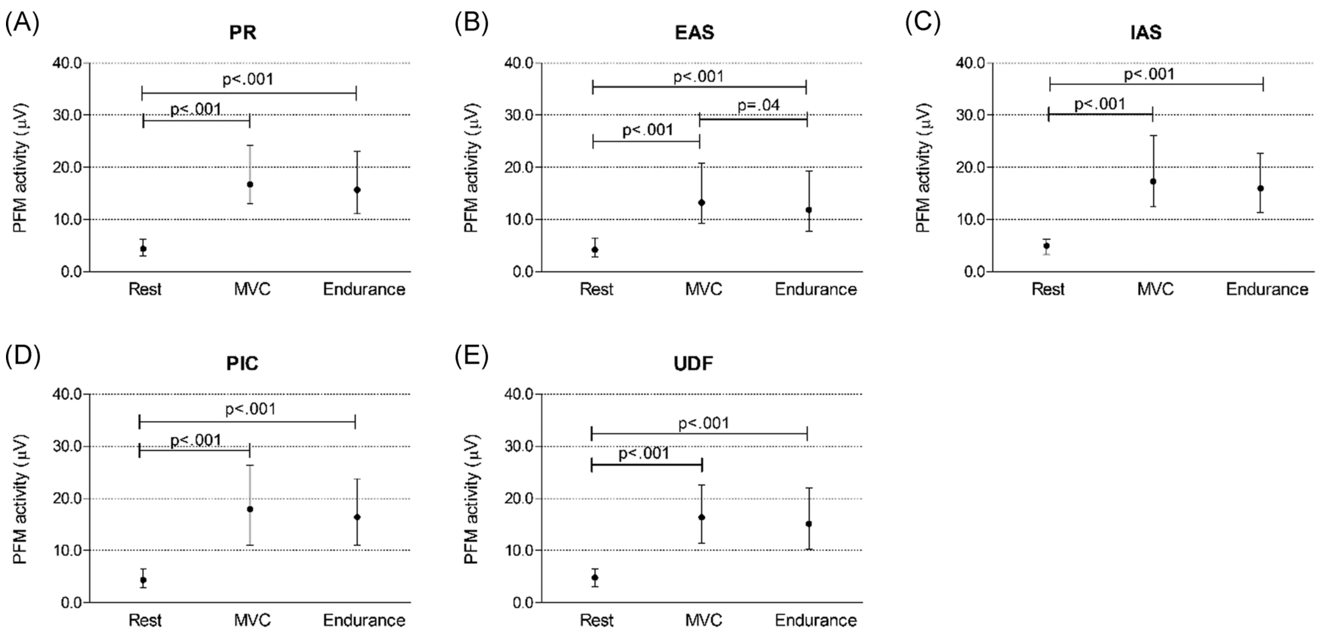

FIGURE 2 A-E, Median microvolt with interquartile range for each of the three tasks (rest, MVC, and endurance) within each muscle group. *P* values reflect the results from the Wilcoxon signed-ranks test between each task. EAS, external anal sphincter; IAS, internal anal sphincter; PFM, pelvic floor muscle; PIC, pubococcygeus and iliococcygeus; PR, puborectalis; UDF, urogenital diaphragm

TABLE 2 Association (Spearman's correlation) between pelvic floor muscle activity and symptoms (IPSS/OABSS) during rest, MVC, and endurance

Measurement	Muscle group	IPSS	OABSS
Rest	Combined	0.08	−0.07
MVC	PR	0.13	0.01
	EAS	0.02	−0.01
	IAS	0.19	0.06
	PIC	0.18	0.08
	UD	0.21	0.09
Endurance	PR	0.14	0.04
	EAS	−0.01	0.08
	IAS	0.10	0.10
	PIC	0.09	0.11
	UDF	0.07	0.06

Note: All values for $P > .005$.
Abbreviations: EAS, external anal sphincter; IAS, internal anal sphincter; IPSS, International Prostate Symptom Score; MVC, maximum voluntary contraction; OABSS, Overactive Bladder Symptom Score; PIC, pubococcygeus and iliococcygeus; PR, puborectalis; UDF, urogenital diaphragm.

floor muscles in LUTS. Indeed, several issues may explain our failure to show an association.

First, we only performed measurements in a symptomatic population, and we did not include an asymptomatic control group. We, therefore, have no normal values against which to compare pelvic floor muscle activity. This is compounded by the fact that the MAPLe device is relatively new and has no large studies. Second, we did not identify subgroups with bladder outlet obstruction, under- or overactive bladder, and dysfunctional voiding. Identifying subgroups rather than including all men with LUTS may reveal important differences in muscle activity. Third, measurements were performed in a resting state and not during the voiding phase or the end of the storage phase when patients with LUTS most often report symptoms. Measuring pelvic floor muscle activity during a pressure-flow study or during uroflowmetry may facilitate the evaluation of the pelvic floor during voiding and storage phases.

TABLE 3 Median pelvic floor muscle activity for men with and without diabetes mellitus, during rest, MVC, and endurance

	Diabetics (n = 5)	Nondiabetics (n = 52)	*P* value*
Rest			
PR	5.60	4.20	.077
EAS	5.68	3.85	.140
IAS	7.55	4.37	.018
PIC	6.95	4.30	.016
UDF	7.32	4.66	.045
MVC			
PR	27.98	16.47	.044
EAS	15.79	13.24	.521
IAS	26.98	16.94	.018
PIC	32.30	17.21	.031
UDF	24.34	15.91	.015
Endurance			
PR	15.39	15.67	.521
EAS	11.78	12.11	.000
IAS	20.87	15.71	.036
PIC	20.20	15.24	.314
UDF	19.91	15.16	.357

Abbreviations: EAS, external anal sphincter; IAS, internal anal sphincter; MVC, maximum voluntary contraction; PIC, pubococcygeus and iliococcygeus; PR, puborectalis; UDF, urogenital diaphragm.
**P* value for Spearman's correlation coefficient.

This study still provides valuable insights into the possible merits of assessing pelvic floor muscle activity with the MAPLe device, despite failing to show a clear association between symptom severity and muscle activity. During the 1-minute rest task, activity did not differ significantly between the five muscle groups, yet during the maximum voluntary contraction task, EAS activity was significantly lower than that of either the IAS or PR. This lower activity could be explained by the EAS containing both slow- and fast-twitch fibers that are subject to fatigue. By contrast, the IAS is an involuntary muscle that follows as a continuation of the inner gastrointestinal wall, and as such, contains smooth slow-wave fibers that may be less prone to fatigue.[10] Given that patients contracted five times for 3 seconds each during the maximum voluntary contractions, exhaustion might have led to less muscle activity in the EAS than in the IAS.

The higher muscle tone in the PR during maximum voluntary contractions could be explained by the instruction given to "hold back bowel movements, passing flatus or gas" during the assessment, which possibly required a lifting action by the PR and less activation of the EAS. Compared with the other muscle groups, which each had similar activities, the EAS also showed significantly less activity during the endurance task. In addition, poor differentiation between the pelvic floor muscles could have resulted from electromagnetic interference between probe signals or from certain muscles having the same distribution. However, we could not easily correct these issues.

Higher activity was shown in the small subgroup of diabetics (n = 5), compared with men without diabetes. As this group was very small and no additional information is known about the duration of the disease, current treatment, and possible complications, it is difficult to explain this outcome in more detail.

In our study, pelvic floor muscle activity was lower for all five muscle groups across all three tasks compared with the results from a study in a healthy cohort of younger participants.[5] The effect of fatigue was reduced in our study by asking participants to perform five rather than ten maximum voluntary contractions and by asking them to perform the three maximal endurance contractions over 15 seconds rather than 30 seconds. An explanation for the lower muscle activity in our study might be that the thickness of the EAS decreases in men as they age.[11] The mean age of men in the present study was 67 years, compared with 41 years in the earlier study.[5] In younger and healthier men, the EAS retains optimal function and thickness that should allow for greater pelvic floor muscle activation.

Future studies must now focus on confirming the normal values for pelvic floor muscle activity, using the MAPLe device. This should include consideration of patient subgroups with different pelvic floor problems and should seek to establish clinically relevant thresholds for abnormality. It would also be interesting to monitor muscle activity during voiding or at the end of the storage phase across all ages in healthy and symptomatic men. This would allow us to evaluate the association of LUTS with pelvic floor dysfunction in greater detail.

5 | CONCLUSION

We are aware of no other research exploring pelvic floor muscle activity in a large group of men with LUTS. Using the MAPLe device, it was possible to differentiate between five muscles or muscle groups in the pelvic floor, but we did not show an association between symptom severity and the activity of those muscles. However, despite our mixed results, we believe that there is sufficient evidence to assert that the presence of an association between pelvic floor muscle activity and LUTS cannot be excluded. Further research is therefore warranted, so we are conducting follow-up research not only to compare pelvic floor muscle activity between males with and without LUTS but also to assess pelvic floor muscle activity during voiding.

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